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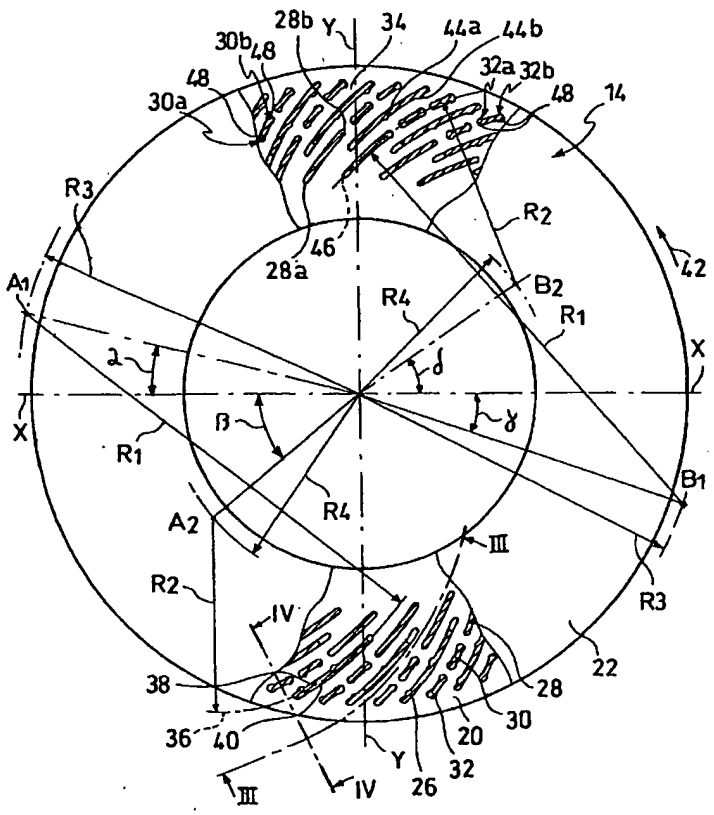
(54) Title: BRAKING BAND AND DISC FOR DISC BRAKE



(57) Abstract: A braking band (14) of a disc-brake disc (10), which has an unusual ability to improve the cooling efficiency of the disc brake, comprises a first plate (20) and a second plate (22) arranged face to face so as to form a space (24). A set of spacer elements (26-32) which connect the first plate (20) and the second plate (22) constitutes a module which is repeated around a circle coaxial with the braking band. The set comprises a first fin (26) which connects the first plate (20) to the second plate (22) and which extends along an arcuate line (36). The set of spacer elements further comprises a second fin (28), a third fin (30), and a fourth fin (32) which connect the first plate (20) to the second plate (22) and which extend along a further arcuate line (46) interposed between two adjacent arcuate lines (36).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DESCRIPTION

"Braking band and disc for disc brake"

The present invention relates to a braking band and to a disc for a ventilated disc brake, particularly but not exclusively for applications in the automotive field.

As is known, a disc of the type specified above is constituted by two coaxial portions. A first portion, the support bell, is for connection to the wheel hub of a vehicle, and the remaining, peripheral portion, the so-called braking band, is for cooperating with the disc-brake calipers to exert the braking force on the vehicle.

It is also known that, during the operation of the brakes, the friction between the pads of the brake calipers and the surface of the braking band generates a large amount of heat which has to be dissipated. The heat generated in fact causes many undesired phenomena such as, for example, the formation of cracks on the braking surface, permanent deformations after cooling, or localized changes in state which in turn lead to vibrations.

In particular, in applications on high-performance motorcars with high braking efficiency, the energy to be dissipated is very high and there is an even greater

need to dissipate the heat generated during braking.

This need for increased cooling efficiency must, however be reconciled with the further need to keep the space occupied by the discs unchanged to avoid modifications to the suspension of the vehicle for which they are intended.

For this purpose, ventilated discs have undergone continuous development, particularly with regard to the number and configuration of the so-called ventilation ducts which are defined between the two plates that conventionally make up ventilated discs, and between fins which connect the two plates transversely.

For example, fins constituted by curved walls repeated at a modular frequency, in which the module itself is constituted by two fins of which one is longer than the other are known from US 5,427,212.

The above-mentioned example of a disc-brake disc cannot ensure effective cooling such as to overcome the above-mentioned disadvantages completely.

The problem underlying the present invention is therefore that of devising a disc-brake disc which has structural and functional characteristics such as to satisfy the above-mentioned requirements and at the same time to prevent the problems mentioned with reference to the prior art.

This problem is solved by a braking band according to Claim 1 and by a disc-brake disc according to Claim 24.

Further characteristics and advantages of the disc-brake disc according to the invention will become clear from the following description of a preferred embodiment thereof, provided by way of non-limiting example with reference to the appended drawings, in which:

Figure 1 is a perspective view of a disc-brake disc according to the invention,

Figure 2 is a partially-sectioned front view of a detail of Figure 1 in the rough, unfinished state,

Figure 3 is a section taken on the line III-III through the detail of Figure 2,

Figure 4 is a section taken on the line IV-VI through the detail of Figure 2,

Figure 5 is a front view of a finished detail of Figure 1,

Figure 6 is a section taken on the line VI-VI through the detail of Figure 5, and

Figure 7 is a perspective view of a disc-brake disc according to a possible variant.

With reference to the above-mentioned drawings, a ventilated disc according to the present invention, for use in a disc brake (not shown) of a vehicle such as a

motorcar, is generally indicated 10.

The disc 10 has a substantially circular shape and extends about an axis indicated Z-Z in Figure 1.

The disc 10 comprises a support bell 12 and a braking band 14 coaxial with the bell 12. The support bell 12 and the braking band 14 may be connected to one another either rigidly or by means of connections which permit differential expansion. An example of a bell 12 and a braking band 14 in the assembled condition is shown in Figure 7. Preferably, the braking band 14 is made of cast iron of the type usually used for brake discs such as, for example, cast iron with a high carbon content.

The support bell 12 comprises a central portion 16 for connection to the wheel hub of a vehicle, in conventional manner, and an annular, peripheral portion 18 which projects from the central portion 16 in a direction substantially parallel to the axis Z-Z.

The braking band 14, which is intended to cooperate with the disc-brake calipers in order to exert the braking force on the vehicle, comprises a first plate 20 and a second plate 22 arranged face to face so as to form an air-outlet space 24. The first plate 20 is disposed on the same side as the support bell 12 and the second plate 22 is disposed on the opposite side.

The second plate 22 is fixed to the first plate 20 by spacer elements and, in the embodiment in question, by fins 26, 28, 30 and 32 which are shaped so as to define ventilation ducts 34.

The fins 26, 28, 30 and 32 form a module which is arranged at predetermined intervals around a circle in the braking band 14 so as to form a plurality of ventilation ducts 34 distributed uniformly around the space between the two plates.

The first fin 26 connects the first plate 20 and the second plate 22 continuously, as can be seen from Figure 4.

An inner end 26a of the first fin 26 is "V"-shaped and has its concavity facing towards the centre of the braking band 14, whereas the outer end 26b of the first fin 26 has a profile substantially perpendicular to the first plate 20 and to the second plate 22.

In greater detail, the "V"-shaped end comprises two straight portions inclined substantially at 45° to the first plate 20 and to the second plate 22 and connected in the region of a centreline of the first fin.

The inner end 26a is positioned on a median circle, that is, a circle with a diameter corresponding to a middle value between the values of the inside diameter and of the outside diameter of the braking band 14, in

the rough, unfinished state (Figure 2). The outer end 26b is positioned in the vicinity of the outer circumference of the braking band 14.

As shown in Figure 2, that is, in a plane parallel to the plates 20 and 22, the first fin 26 extends along an arcuate line, indicated 36, relative to which a concave surface 38 and a convex surface 40 of the first fin can be defined.

An arrow representing the principle direction of rotation of the disc 10, that is, the direction of rotation corresponding to the forward direction of movement of the vehicle, is indicated 42.

Relative to this direction of rotation, the first fin 26 is arranged substantially in a manner such that the concave surface 38 and the convex surface 40 are upstream and downstream of the arcuate line 36, respectively.

The arcuate line 36 extends continuously along two circles which are defined below with reference to the system of Cartesian axes X and Y shown in Figure 2.

In fact, the inner portion of the first fin 26, that is the portion closest to the axis Z-Z, extends along a portion of a circle of radius R_1 and of centre A_1, whereas the outer portion of the first fin 26, that is the portion farthest from the axis Z-Z, extends along

a portion of a circle of radius R_2 and of centre A_2.

The radius R_1 of the inner portion of the first fin 26 is greater than the radius R_2 of the outer portion of the first fin 26.

The positions of the above-mentioned two centres A_1 and A_2 are also indicated in Figure 2. In particular, the centre A_1 is disposed on a circle of radius R_3, outside the braking band 14, whereas the centre A_2 is disposed on a circle of radius R_4 having a diameter between the inside diameter and the outside diameter of the rough, unfinished braking band 14.

The outer portion of the first fin 26 is thus more arcuate than its inner portion and the outer portion of the respective ventilation duct 34 consequently deviates further in the direction contrary to the direction of rotation of the disc 10.

In Figure 2, at the dimensional control stage, the centre A_1 is given by the intersection of the circle of radius R_3 and a straight line extending through the centre of the system of axes X and Y and inclined at an angle α of about 14° to the axis X. Similarly, the centre A_2 is given by the intersection of the circle of radius R_4 and a straight line extending through the centre of the system of axes X and Y and inclined at an angle β of about 40° to the axis X.

The first fin 26 also comprises two projections 44a and 44b which project from the concave surface 38 towards the interior of the ventilation duct 34. The first projection 44a is positioned approximately centrally relative to the length of the first fin 26, whereas the second projection 44b is positioned in the vicinity of the outer end 26b.

The first fin 26 is repeated around the space 24 at predefined intervals which permit the production of a disc with about 20-50 first fins.

The further fins 28, 30 and 32 which, for simplicity of explanation, will be indicated as a second, a third, and a fourth fin, are positioned along further arcuate line, indicated 46.

This further arcuate line 46 is offset relative to the arcuate line 36 by a distance equal to half of the intervals at which the arcuate lines 36 are repeated. The alternating arrangement of the first fin 26 along the arcuate line 36 and of the other fins 28, 30 and 32 along the further arcuate line 46 permits the production of a disc with approximately 40-100 ventilation ducts 34.

The further arcuate line 46 also extends continuously along two circles which are defined below with reference to the system of Cartesian axes X and Y

shown in Figure 2.

In fact, the inner portion of the arcuate line 46, that is the portion closest to the axis Z-Z, extends along a portion of a circle of radius R_1 and of centre B_1, whereas the outer portion of the further arcuate line 46, that is the portion farthest from the axis Z-Z, extends along a portion of a circle of radius R_2 and of centre B_2.

The radius R_1 of the inner portion of the arcuate line 46 is greater than the radius R_2 of the outer portion of the arcuate line 46 and, in particular, these radii correspond to the respective radii defining the arcuate line 36 of the first fin 26.

The outer portion of the further arcuate line 46 is therefore more arcuate than its inner portion and the outer portion of the respective ventilation duct 34 consequently deviates further in the direction contrary to the direction of rotation of the disc 10. All of the ventilation ducts 34 therefore deviate in the same direction, contrary to the direction of rotation of the disc.

The positions of the two above-mentioned centres B_1 and B_2 are indicated in Figure 2. According to the preferred embodiment shown in Figure 2, the centre B_1 is disposed on a circle of radius R_3 outside the braking

band 14, whereas the centre B_2 is disposed on a circle of radius R_4 having a diameter between the inside diameter and the outside diameter of the braking band 14. As can readily be inferred from the foregoing statements, the centre A_1 and the centre B_1 preferably lie on the same circle of radius R_3 and, similarly, the centre A_2 and the centre B_2 preferably lie on the same circle of radius R_4.

In Figure 2, at the dimensional control stage, the centre B_1 is given by the intersection of the circle of radius R_3 with a straight line extending through the centre of the system of axes X and Y and inclined at an angle γ of about 19° to the axis X. Similarly, the centre B_2 is given by the intersection of the circle of radius R_4 with a straight line extending through the centre of the system of axes X and Y and inclined at an angle δ of about 34° to the axis X.

As mentioned above, the second fin 28, the third fin 30, and the fourth fin 32 are disposed along the further arcuate line 46.

The second fin 28 connects the first plate 20 and the second plate 22 continuously. Moreover, the second fin 28 has an inner end 28a disposed in the vicinity of the inner diameter of the braking band 14 in the rough, unfinished state and an outer end 28b corresponding to

the output edge and disposed slightly beyond the above-mentioned median circle, that is, the circle of mean diameter between the inside and outside diameters of the braking band 14 in the rough, unfinished state.

In a substantially finished braking band 14, the second fin 28 adopts the configuration shown in Figure 5, in which the machining undergone by the first end 28a is clear.

The third fin 30 is disposed along the same arcuate line 46 in a manner such that an inner end 30a thereof is disposed slightly beyond the above-mentioned median circle and an outer end 30b thereof is disposed in the vicinity of a circle of mean diameter between the diameters of the above-mentioned median circle and the outer circumference of the braking band 14.

Both the inner end 30a and the outer end 30b have portions 48 which are enlarged in comparison with the thickness of the fin itself.

As shown in Figure 2, the third fin 30 is disposed substantially in an annular region between the two projections 44a and 44b of the first fin 26.

Finally, the fourth fin 32 is disposed along the further arcuate line 46. This last fin has an inner end 32a disposed on a circle substantially corresponding to the second projection 44b of the first fin 26 and an

outer end 32b disposed in the vicinity of the outer circumference of the braking band 14.

The fourth fin 32 is structurally identical to the third fin 30, since both its inner end 32a and its outer end 32b have portions 48 which are enlarged in comparison with the thickness of the fin itself.

The disc-brake disc according to the invention satisfies the above-mentioned requirement and prevents the problems mentioned with reference to the prior art. In fact, as explained above, the structure of the disc according to the invention increases cooling efficiency, as is shown by the test results obtained and given in the following table, with a disc-brake disc produced in accordance with the teaching of US 5,427,212 as a control:

	US 5,427,212	Present invention
Weight (kg)	5,900	5,780
Disc temperature [°C]	490	470
Pad temperature [°C]	480	450
Caliper-fluid temperature [°C]	130	120
Pad wear [mm]	6.9	6.7
"Disc stiffness" parameter	5.4	5.3

The second column relates to a disc having the

characteristics described in US patent 5,427,212, that is, a ventilated disc forming part of the prior art and selected as a control. The third column, on the other hand, relates to a disc which has the above-described characteristics and hence to a disc according to the present invention.

The individual parameters taken into consideration have the following significance. In the first place, the term "weight" means the weight of the machined, finished braking band 14 (Figure 5).

The disc temperature corresponds to the temperature of the surface of the braking band 14 measured at the start of one of the braking operations after the disc has been brought to steady-state conditions during the test cycle.

The pad temperature corresponds to the mean temperature of the pad measured at the same moment at which the disc temperature was measured.

The term "caliper-fluid temperature" means the maximum temperature of the brake fluid in the caliper, measured at the end of the test cycle.

The term "pad wear" indicates the mean wear of the pads upon completion of the test cycle.

Finally, the expression "disc stiffness" defines an index of the travel of the brake pedal, evaluated as the

pressure which the pump manages to develop for each millimetre of travel of the caliper piston.

The results given above were obtained with a test cycle on a dynamometric bench, the test parameters being kept constant in both of the cases considered. In particular, the parameters which were kept constant were the energy dissipated upon each braking operation, the time between the start of one braking operation and the start of the next braking operation, the torque developed during each braking operation and the number of braking operations.

As can be appreciated from the foregoing description, it is clear that the novel configuration of the fins, and consequently of the ventilation ducts, enables greater cooling efficiency to be achieved.

A further advantage of the disc-brake disc according to the invention lies in the fact that it is structurally and functionally simple so that it is inexpensive to produce and ensures reliable operation over time.

Naturally, in order to satisfy contingent and specific requirements, a person skilled in the art may apply to the disc-brake disc according to the invention many modifications and variations all of which, however, are included within the scope of protection of the

invention as defined by the appended claims.

For example, the projections or the enlarged portions may have shapes, sizes and positions other than those described and illustrated.

Moreover, the braking surfaces may equally well be smooth, perforated, or with either linear or arcuate grooves, or may be both perforated and grooved.

CLAIMS

1. A braking band (14) for a disc-brake disc (10), comprising:

a first plate (20) and a second plate (22), arranged face to face so as to form a space (24),

a set of spacer elements (26-32) which connect the first plate (20) and the second plate, the set constituting a module which is repeated around a circle coaxial with the braking band,

the set of spacer elements comprising a first fin (26) which connects the first plate (20) to the second plate (22) and which extends along an arcuate line (36),

the set of spacer elements further comprising a second fin (28), a third fin (30), and a fourth fin (32) which connect the first plate (20) to the second plate (22) and which extend along a further arcuate line (46) interposed between two adjacent arcuate lines (36).

2. A braking band according to Claim 1 in which the arcuate line (36) extends along portions of two circles.

3. A braking band according to Claim 2, in which an inner portion of the arcuate line (36) extends along a portion of a circle having a radius R_1 and a centre A_1, and an outer portion of the arcuate line (36) extends along a portion of a circle having a radius R_2 and a centre A_2, R_1 being greater than R_2.

4. A braking band according to Claim 3 in which A_1 is further from the centre of the braking band than A_2.

5. A braking band according to Claim 4 in which A_1 lies on a circle of radius R_3 outside the outer circumference of the braking band (14) and A_2 lies on a circle of radius R_4 disposed between the outer circumference and the inner circumference of the rough, unfinished braking band (14).

6. A braking band according to one or more of the preceding claims, in which the further arcuate line (46) extends along portions of two circles.

7. A braking band according to Claim 6 in which an inner portion of the further arcuate line (46) extends along a portion of a circle of radius R_1 and centre B_1, an outer portion of the further arcuate line (46) extends along a portion of a circle of radius R_2 and centre B_2, R_1 being greater than R_2.

8. A braking band according to Claim 7 in which B_1 is further from the centre of the braking band than B_2.

9. A braking band according to Claim 8 in which B_1 lies on a circle of radius R_3 outside the outer circumference of the braking band (14) and B_2 lies on a circle of radius R_4 disposed between the outer circumference and the inner circumference of the rough, unfinished braking band (14).

10. A braking band according to Claims 3 and 7 in which the radii of the circles along which the inner portions of the arcuate line (36) and of the further arcuate line (46) extend are identical.

11. A braking band according to Claims 3 and 7 in which the radii of the circles along which the outer portions of the arcuate line (36) and of the further arcuate line (46) extend are identical.

12. A braking band according to Claims 5 and 9 in which B_1 lies on the same circle of radius R_3 on which the centre A_1 lies.

13. A braking band according to Claims 5 and 9 in which B_2 lies on the same circle of radius R_4 on which the centre A_2 lies.

14. A braking band according to Claim 1 in which the first fin (26) comprises at least one projection (44a, 44b).

15. A braking band according to Claim 14 in which the at least one projection (44a, 44b) is disposed on a concave surface (38) of the first fin (26).

16. A braking band according to Claim 15 in which the concave surface (38) comprises a first projection (44a) positioned approximately centrally relative to the length of the first fin (26) and a second projection (44b) positioned in the vicinity of an outer end (26b)

of the first fin (26).

17. A braking band according to Claim 1 in which the first fin (26) comprises an inner end (26a) positioned on a circle of substantially mean diameter between the inside and outside diameters of the rough, unfinished braking band (14).

18. A braking band according to Claim 1 in which the first fin (26) comprises a "V"-shaped inner end (26a).

19. A braking band according to Claim 18 in which the "V"-shaped inner end (26a) has its concavity facing towards the centre of the braking band.

20. A braking band according to Claim 1 in which the second fin (28) comprises an inner end (28a) disposed in the vicinity of the inner circumference of the braking band (14) and an outer end (28b) disposed in the vicinity of a circle of substantially mean diameter between the inside and outside diameters of the rough, unfinished braking band (14).

21. A braking band according to Claim 1 in which the third fin (30) comprises an inner end (30a) disposed in the vicinity of a median circle of substantially mean diameter between the inside and outside diameters of the rough, unfinished braking band (14), and an outer end (30b) disposed in the vicinity of a circle of mean

diameter between that of the median circle and the outer circumference of the braking band (14).

22. A braking band according to Claim 1 in which the third fin (30) comprises an inner end (30a) and an outer end (30b) having portions (48) which are enlarged in comparison with the thickness of the third fin.

23. A braking band according to Claim 1 in which the fourth fin (32) comprises an inner end (32a) and an outer end (32b) having portions (48) which are enlarged in comparison with the thickness of the fourth fin.

24. A disc-brake disc (10) comprising a braking band (14) according to one or more of Claims 1 to 23.

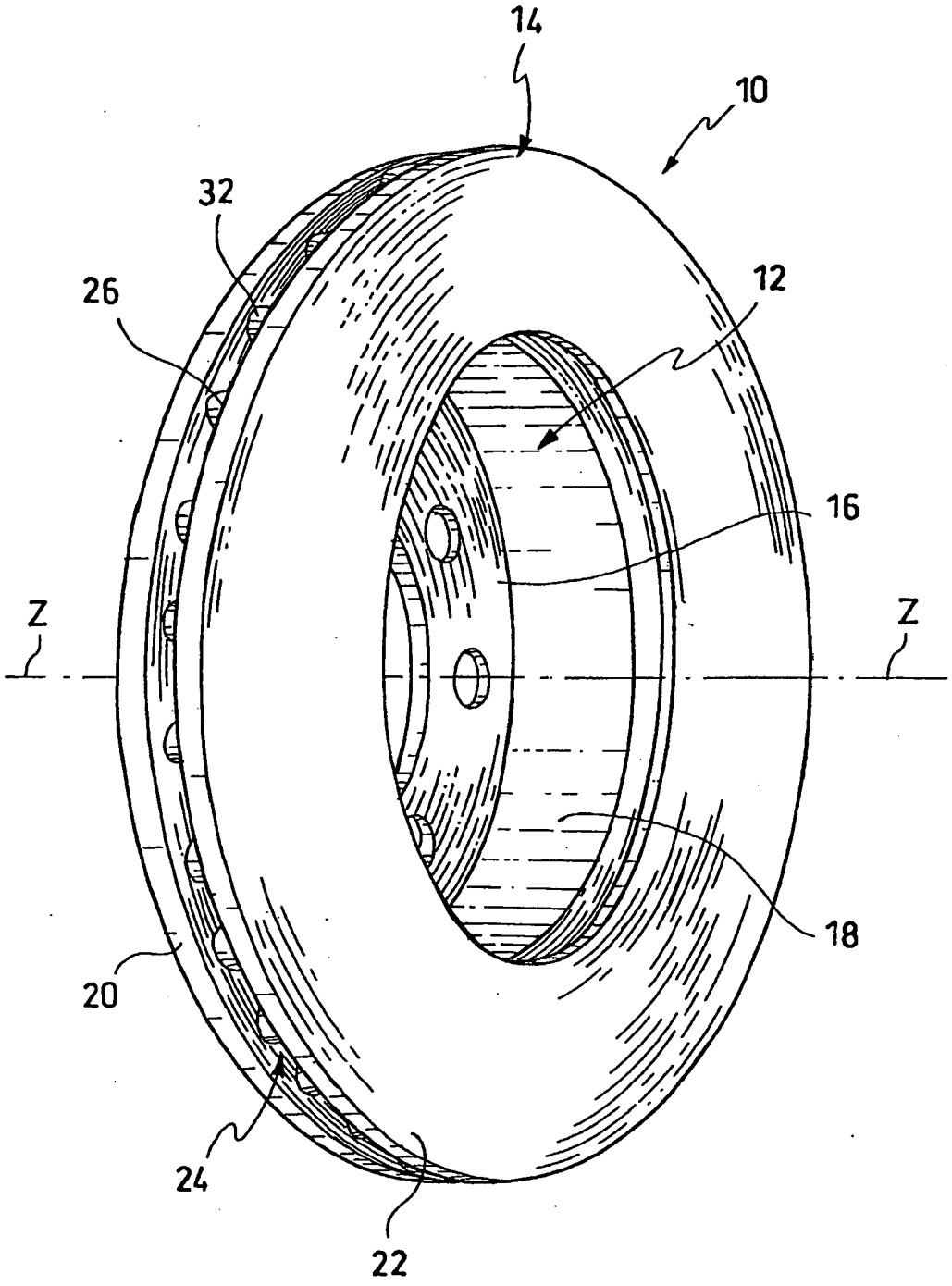
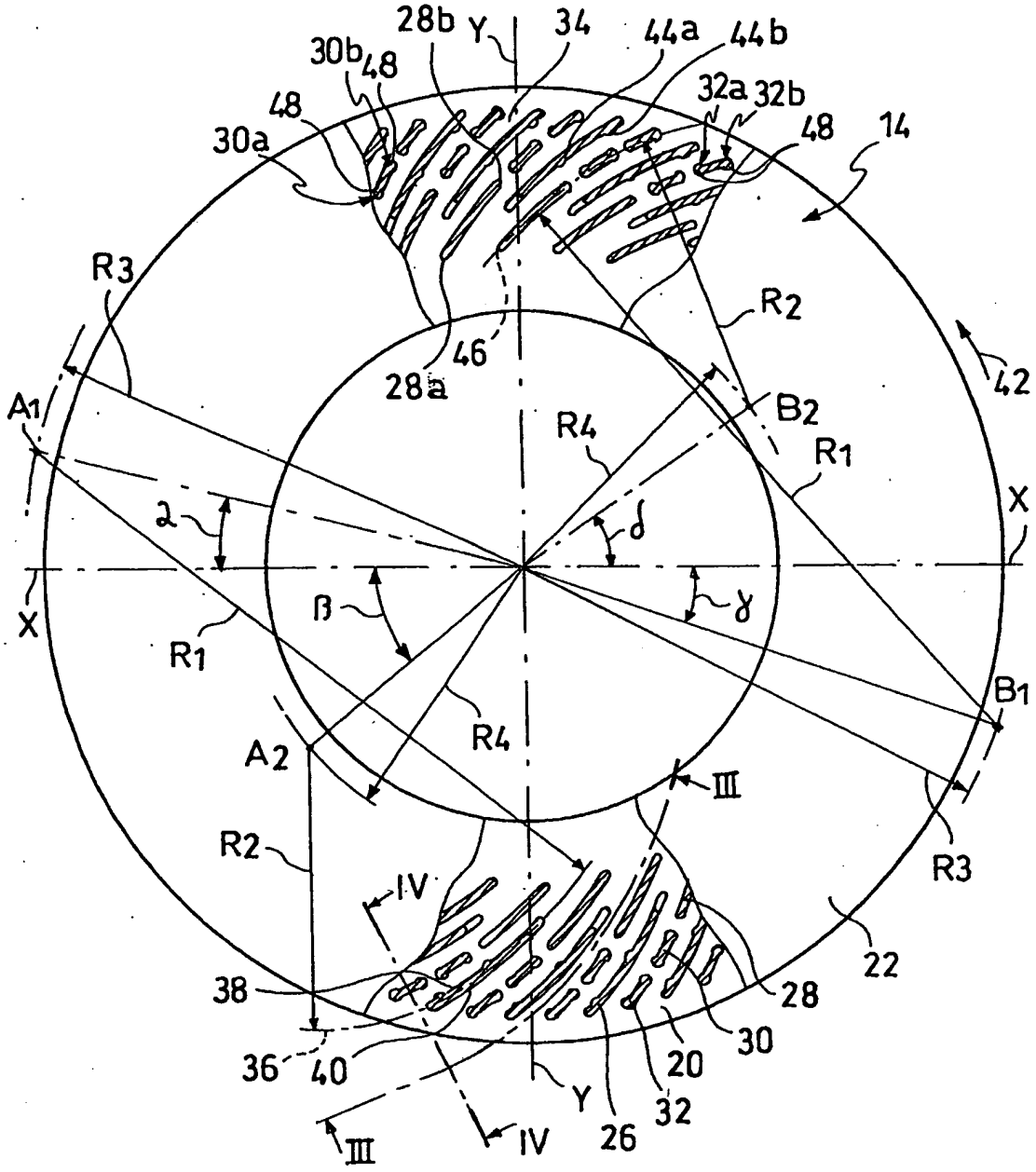


FIG.1


28b
Y
34
44a
44b
30b
48
32a
32b
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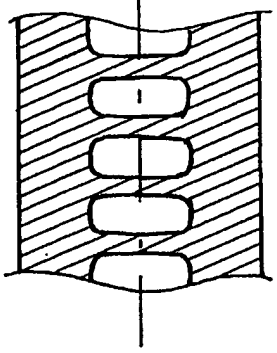
48
14
30a
R3
R2
46
28a
42
A1
B2
R4
R1
X
α
δ
β
γ
X
R1
B1
R4
A2
III
R2
IV
R3
22
38
28
30
36
40
20
Y
32
III
IV
26

FIG. 2

FIG.4



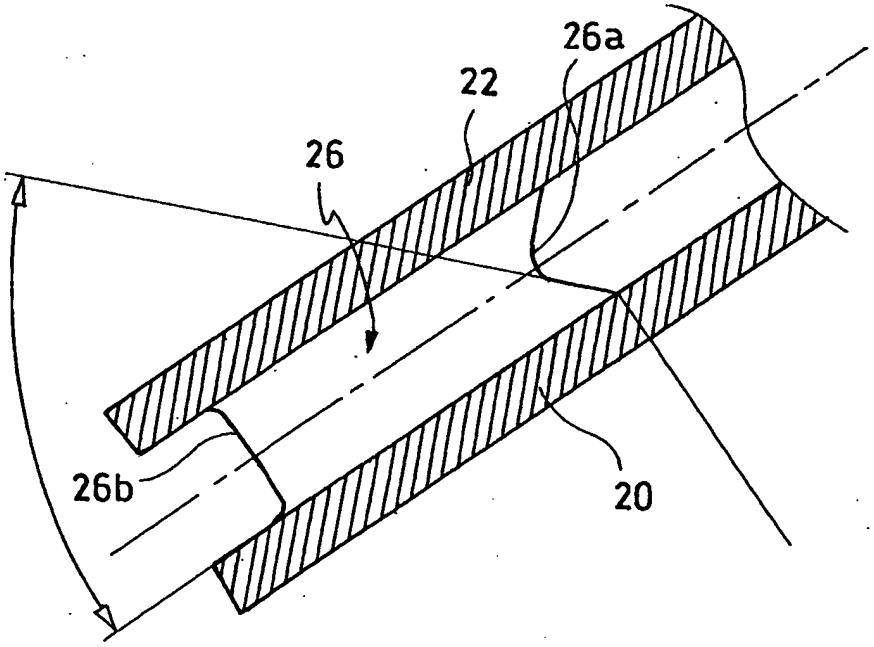


FIG.3

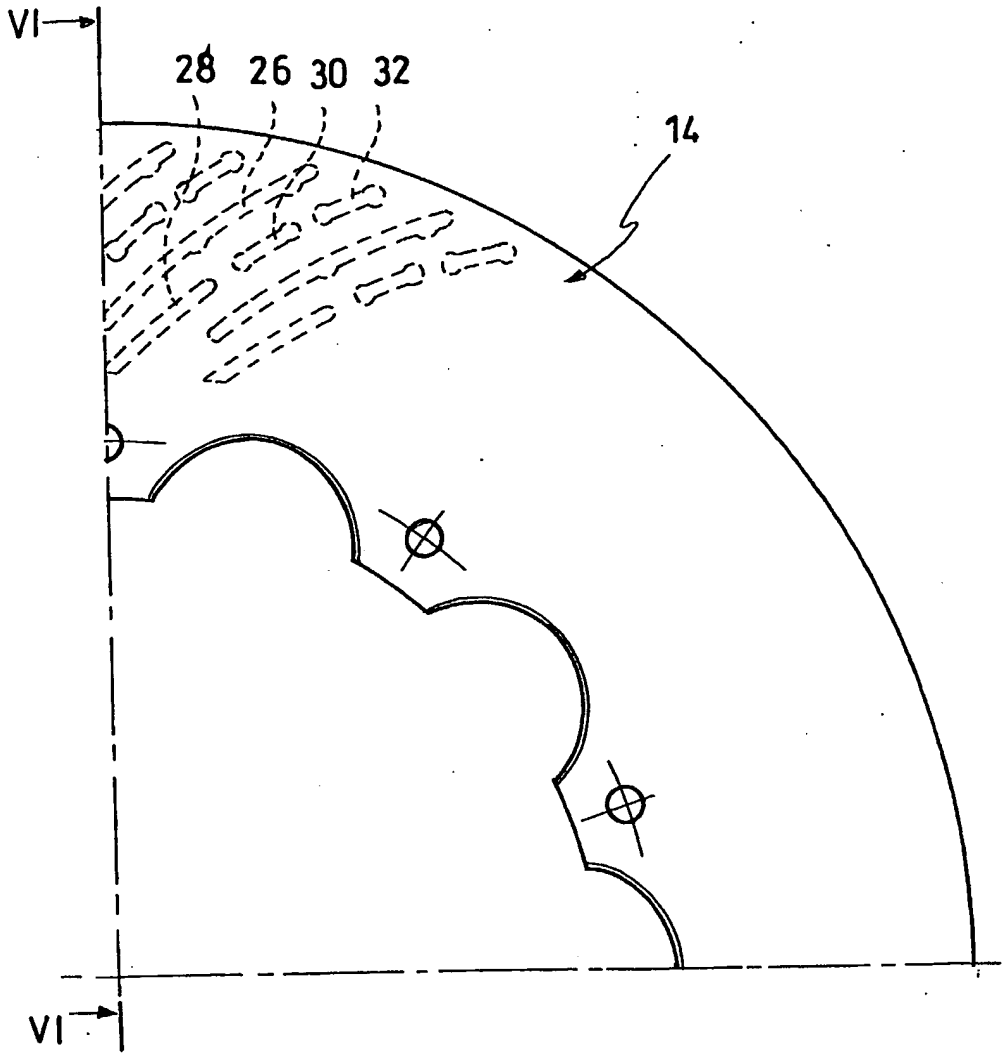


FIG. 5

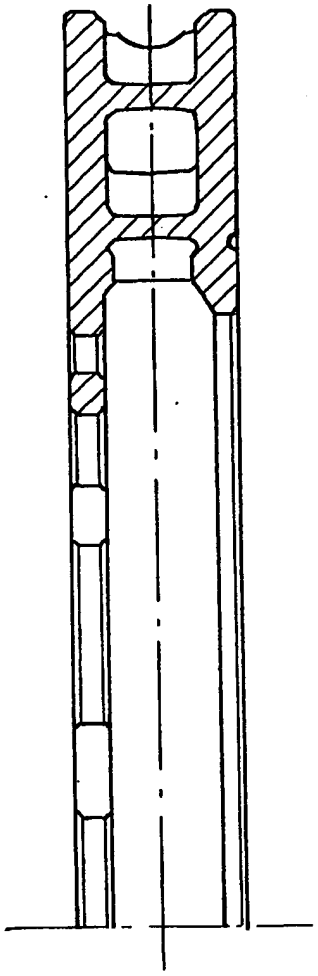


FIG.6

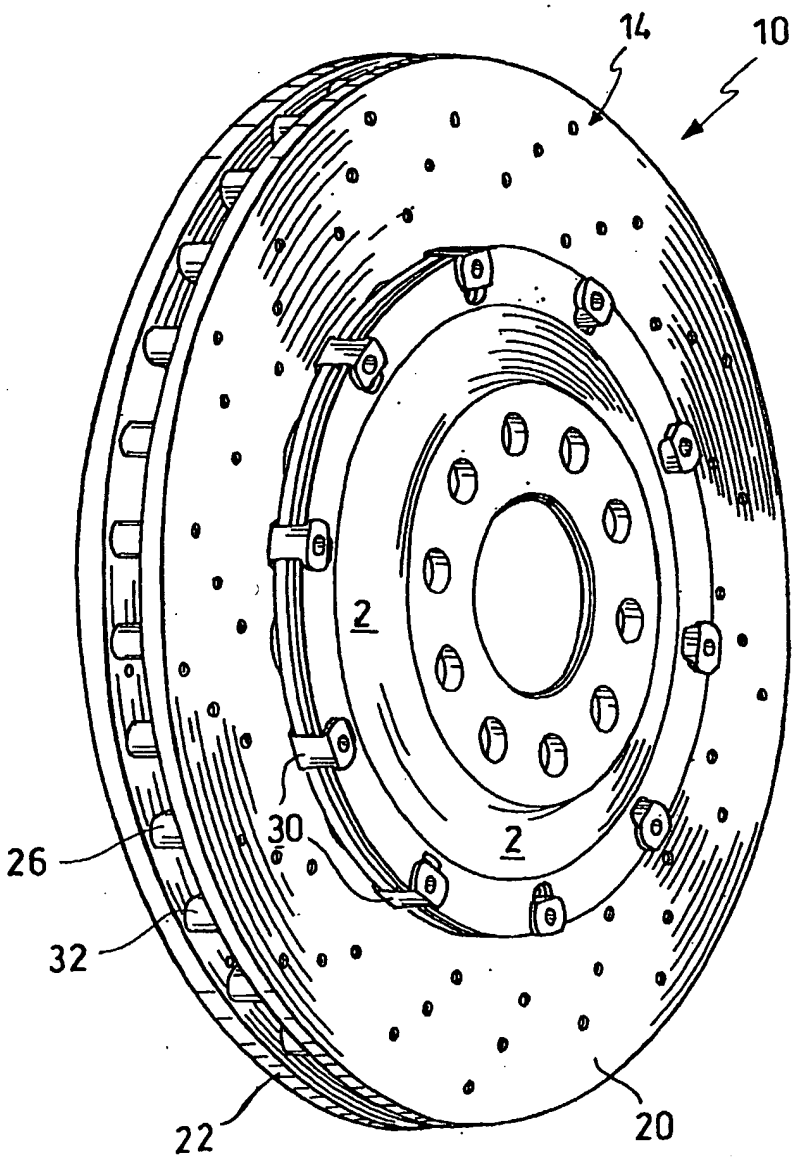


FIG.7

INTERNATIONAL SEARCH REPORT

In ›nal Application No
PCT/IT 01/00129

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16D65/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16D F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 712 656 A (COURTOIS JEAN-CLAUDE) 15 December 1987 (1987-12-15) column 1, line 55 -column 2, line 24 column 3, line 14 - line 61; figure 1	1-4,6-8, 10,11, 17,20,21
Y		14-16, 18,19, 22-24
Y	DE 43 32 693 A (PORSCHE AG) 30 March 1995 (1995-03-30) claim 3; figure 1	14-16, 22-24
Y	GB 847 120 A (AMERICAN STEEL FOUNDRIES) 7 September 1960 (1960-09-07) page 2, line 86 - line 121; figure 3	18,19
	-/—	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2001	04/09/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Topolski, J

Form PCT/ISA/210 (second sheet) (July 1992)

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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